GEFÖRDERT VOM

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CO_2 fluxes before and after partial deforestation of a spruce forest

Patrizia Ney[1], Marius Schmidt[1], Heye Bogena[1], Bernd Diekkrüger[2], Clemens Drüe[3], Odilia Esser[1], Günther Heinemann[3], Anne Klosterhalfen[1], Katharina Pick[1], Thomas Pütz[1], Veronika Valler[4], Harry Vereecken[1], Alexander Graf[1]

(1) Agrosphere (IBG-3), Forschungszentrum Jülich, Germany (2) Institute of Geography, University of Bonn, Germany

(3) Department of Environmental Meteorology, University of Trier, Germany (4) Institute of Geography, University Bern, Switzerland

Introduction and aim

- disturbances of forest ecosystems lead to changes in their functional characteristics, e. g., deforestation has a large impact on carbon dioxide (CO_2) exchange between forest ecosystem and the atmosphere: after clear-cutting, a former forest sink can become a source for CO_2
- measured net CO_2 exchange (NEE) is the balance between carbon fixed by photosynthesis (gross primary production, GPP) and release through ecosystem respiration (R_{eco}) → **NEE = -GPP + R_{eco}**

Our aim: quantifying the magnitude of the initial sink-source strength change of CO_2 and the pace of recovery during the first years after deforestation.

Test site and CO_2 flux measurements

- **TERENO** research site Wüstebach (50.5°N, 6.3°E, ~610 m a.s.l.):
- annual averaged temperature and precipitation: 8.2 °C, 1160 mm
- Wüstebach catchment: 38.5 ha of a 70-year-old spruce monoculture (*Picea abies L.*)
- 8.6 ha deforested → natural regeneration towards deciduous vegetation
- 1st year after clear-cutting: mainly grasses (*Deschampsia flexuosa Trin.*)
- 2nd year: young trees (mountain ash *Sorbus aucuparia L.*) and shrub vegetation

measurements in forest (since June 2010):

- meteorological tower (37.8 m a.g.l.),
- eddy covariance (EC) station: fluxes of CO_2, H_2O and heat (EC 1)

clearcut (since September 2013):

- second EC station (up to 3.0 m a.g.l., EC 2)
- soil respiration (R_s) measurements with portable soil CO_2 flux chambers at 25 x 3 transect locations (Fig.1)

EC site-years

	forest station	clearcut station
before clearcut	3	-
after clearcut	4	4

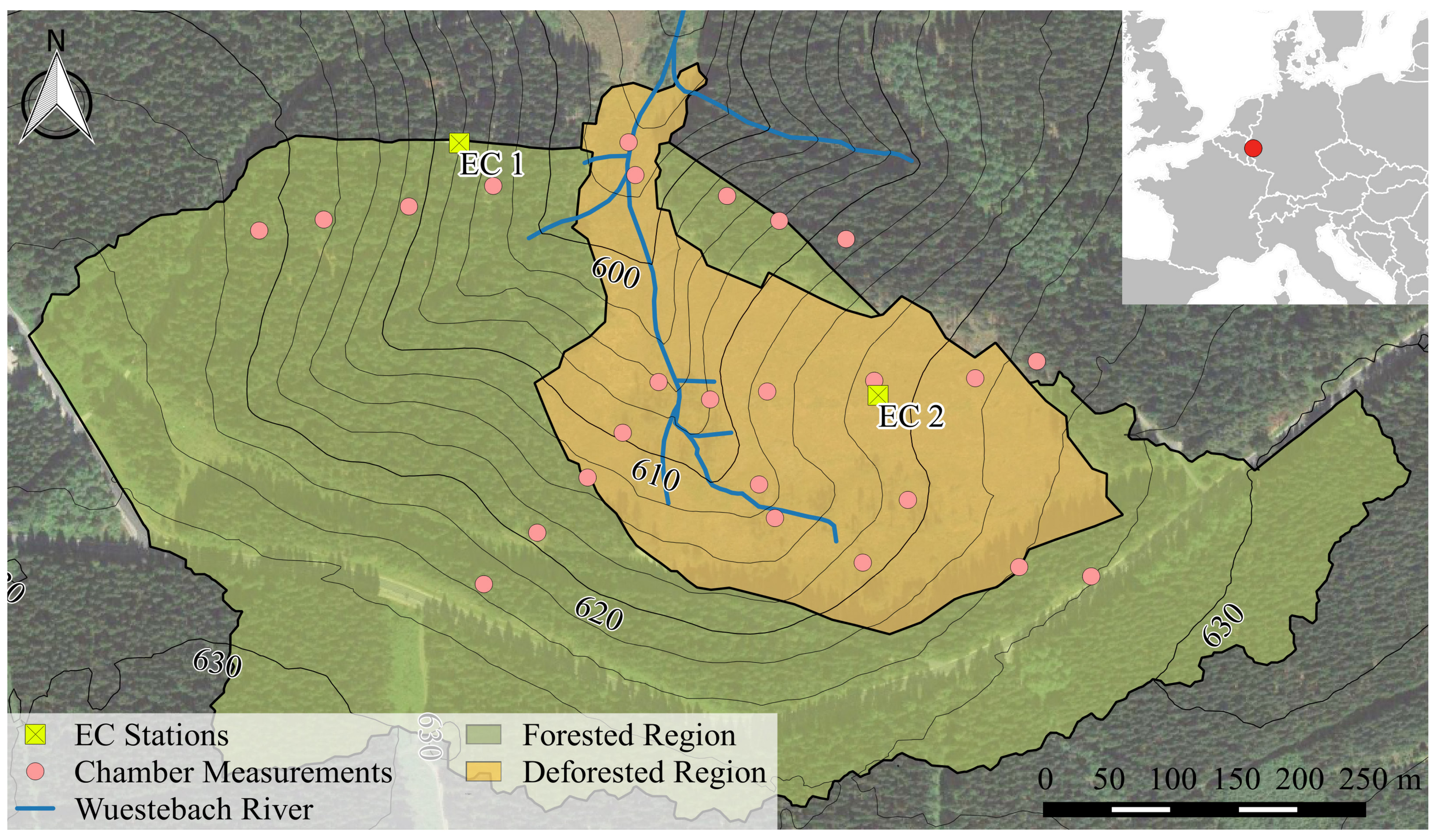

Fig. 1: Map of the Wüstebach catchment with locations of the measurements after partial deforestation in September 2013.

Results

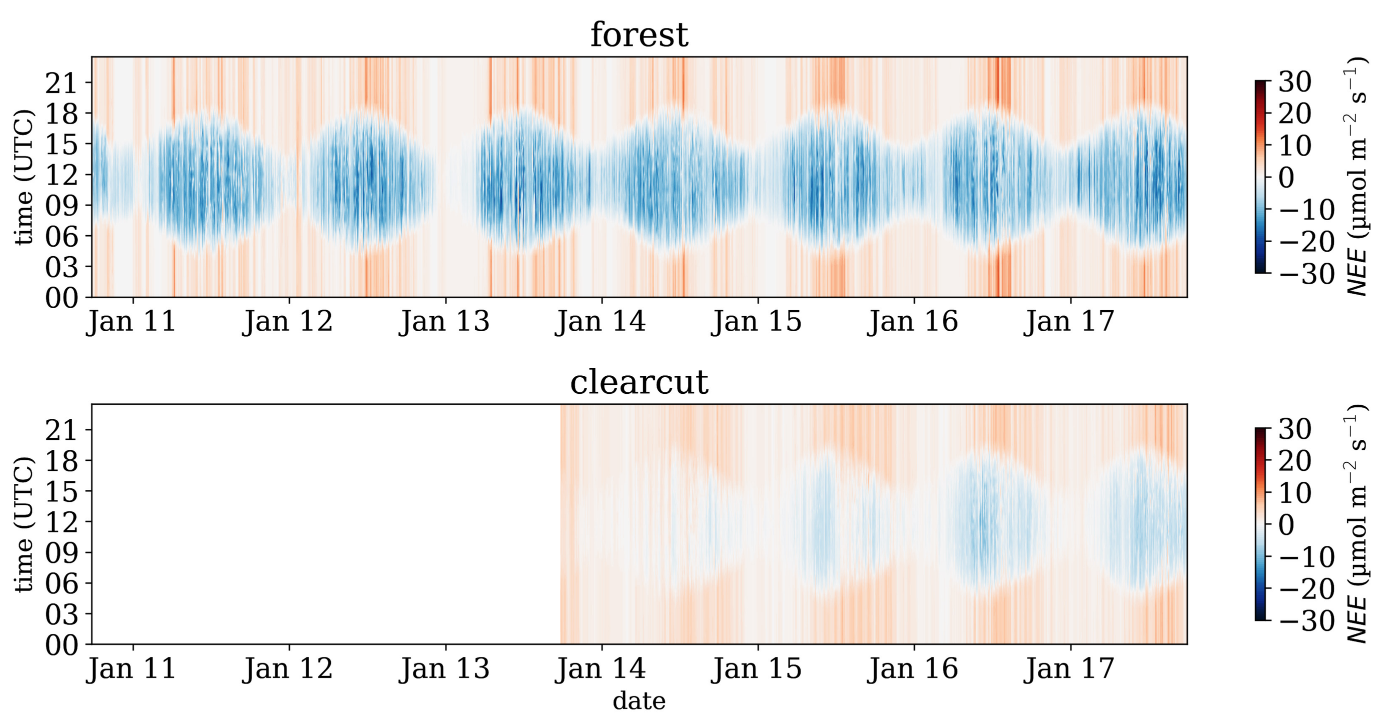

Fig.2: Half-hourly values of NEE (gap-filled after Lasslop, 2010). Positive (red) values indicate a release from the ecosystem to the atmosphere and vice versa. At the forest site, the amplitude between CO_2 uptake (blue, daytime) and release (night) was in general higher than in the deforested area due to higher amount of biomass. The amplitude of NEE in the deforested area increased year by year due to regrowing vegetation.

annual total carbon fluxes forest area

(g C m^{-2})	y1	y2	y3	y4	y5	y6	y7
NEE	-587	-664	-680	-761	-759	-658	-530
GPP	1515	1622	1569	1738	1816	1738	1760
R_{eco}	928	958	889	997	1057	1080	1230

annual total carbon fluxes deforested area

	y1	y2	y3	y4	y5	y6	y7
NEE	-	-	-	521	283	95	83
GPP	-	-	-	385	670	923	892
R_{eco}	-	-	-	906	953	1018	975

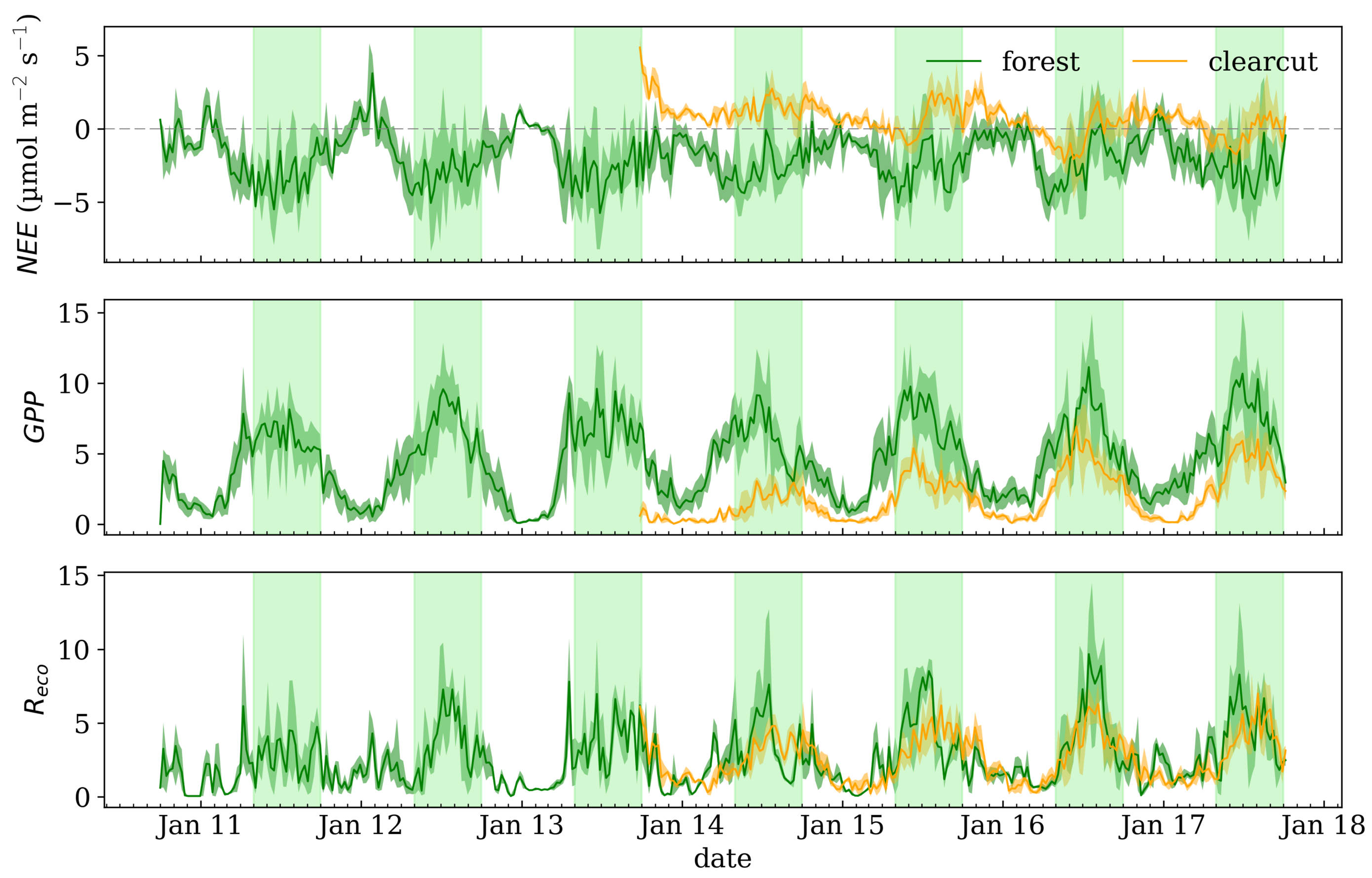

Fig.3: Forest NEE mostly negative, uptake occurs even in winter due to conifers

Clearcut NEE mostly positive, negative in early growing season from its 2nd year on

Small inter-annual variability in forest GPP and R_{eco}.

Low clearcut GPP due to reduced photosynthetic uptake, tripled in the last year with recovering vegetation.

Clearcut R_{eco} was smaller in the first year, increasing trend over years, currently significantly larger than forest R_{eco}.

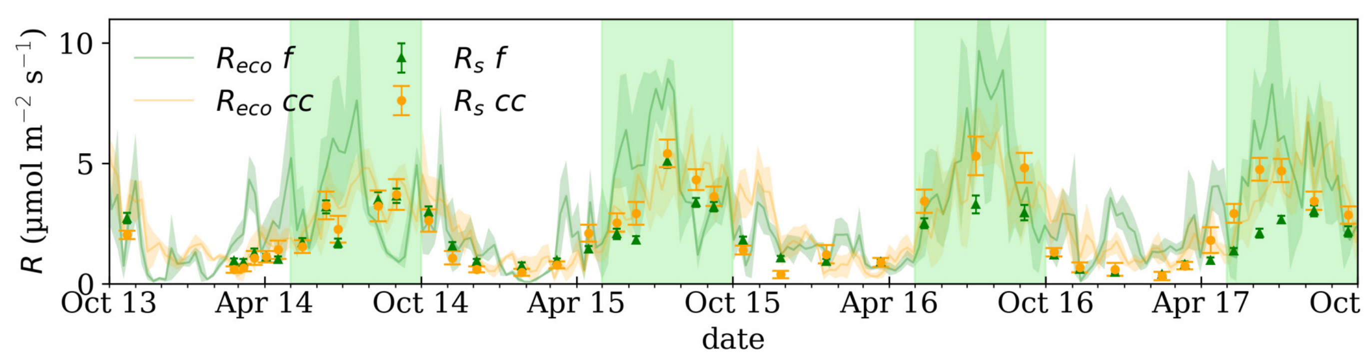

Fig.4: Significant differences in R_s in the last two years, clearcut R_s > forest R_s in the growing season. Contribution of R_s to R_{eco} higher on the clearcut (50%, forest 40%) due to less aboveground biomass.

Radiative forcing (*RF*) estimated after Betts (2000), Myhre et al. (1998) and Rotenberg & Yakir (2010): cooling effect of ΔRF_{albedo} overrides warming effect of ΔRF_{NEE} of the increased NEE release. Decreasing albedo due to a higher proportion of woody vegetation will weaken the cooling effect in the future but not completely return to low spruce value, while ΔRF_{NEE} is expected to stop increasing or decrease.

radiative forcing of albedo and CO_2 effect (ΔRF and $\sum_{Forcing}$ in 10^{-14} W m^{-2} global m^{-2} treated surface, $\Delta NEE_{f,cc}$ in g C m^{-2})

	y4	y5	y6	y7
albedo f	0.07	0.07	0.07	0.07
albedo cc	0.16	0.22	0.25	0.21
$\Delta NEE_{f,cc}$	1282	1042	753	613
ΔRF_{albedo}	-2.1	-3.56	-4.19	-3.23
ΔRF_{NEE}	0.4	0.73	0.96	1.16
$\sum_{Forcing}$	-1.7	-2.83	-3.23	-2.08

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